

# 3 Design Factors



*An example of a bicycle-pedestrian bridge.*

Planners and engineers have a wide range of options to enhance bicycle transportation. On the one hand, improvements can be simple, inexpensive and involve minimal design consideration. An example might be approving a change in bicycle-safe drainage grates used on local road projects. On the other hand, improvements can involve substantial allocations of funds, detailed design, and multi-year commitments to phased development. An example might be an extensive community-wide bicycle path network.

In order to adequately design for bicyclists, particularly when approaching large-scale projects, one must have a basic understanding of how bicycles operate. Most designers have an understanding of motor vehicle operation, but few have studied bicycle operation closely.

## **Bicycle and bicyclist characteristics**

The physical space occupied by a bicycle is relatively modest. Generally, bicycles are between 600 mm and 750 mm (24 in and 30 in) wide from one end of the handlebars to the other. An adult tricycle or a bicycle trailer, on the other hand, is approximately 0.8 m to 1 m (32 in to 40 in) wide. The length of a bicycle is approximately 1.75 m (70 in); with a trailer, the length grows to 2.55 m to 2.75 m (102 in to 110 in). In determining the design of off-road facilities, the width is more critical than the length.

The height of an adult bicyclist on a bicycle is given as 2.3 m (88 in). This height takes into consideration the possibility that the bicyclist may be riding while standing up. Generally, adult riders are between 1.5 m and 1.8 m (60 in and 72 in) high while riding on the saddle.

While these dimensions give the physical space occupied by the bicycle and rider, the bicycle in motion requires additional space. One must also consider clearances and maneuvering allowances between the bicycle and static or moving obstructions. The following are typical clearances used in determining widths of bicycle facilities:

### Typical clearances:

#### Maneuvering allowances:

To edge of pavement .....	0.3 m (1.0 ft)
Between bikes .....	0.8 m (2.5 ft)
Between bikes and peds ...	0.8 m (2.5 ft)

#### Lateral clearances:

To parked cars .....	0.6 m (2.0 ft)
To curb drop-off .....	0.6 m (2.0 ft)
To utility poles, trees, and hydrants.....	0.6 m (2.0 ft)
To soft shoulder .....	0.45 m (1.5 ft)
To sloped drop-off .....	0.3 m (1.0 ft)

#### Vertical clearance:

To overhead obstruction...	0.6 m (2.0 ft)
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Source: Bikeway Planning Criteria and Guidelines; ITTE, 1972

In determining design speeds, it is important to consider the average speeds of typical bicyclists, as well as other likely users. Studies have shown that the average speed of bicyclists is 16 km/h (10 mph). However, these studies may not account for the growing number of riders, whose speeds may easily exceed 32 km/h (20 mph).

An important consideration in setting bicycle path curve radii, particularly those on downgrades is the effect of speed on turning ability. When traveling at average speeds, a bicyclist cannot turn the handlebars more than a few degrees to either side without losing control.

Further, while bicyclists can lean into turns, few riders are comfortable leaning at angles above five to ten degrees. To do so puts the inexperienced rider at risk of either sliding out or hitting the inside pedal on the pavement. As a result of these factors, bike path curve radii should be designed in a conservative manner.

Another critical characteristic is stopping distance. Due to differences in brake type and quality and rider skill, stopping distances for

bicyclists traveling at the same speed may vary dramatically. Some bicycles are equipped with coaster brakes attached to the rear wheel hub; others use caliper brakes that act on both wheels. Further differences are found between high quality caliper brakes with special brake pads and inexpensive ones equipped with relatively slick pads.

In addition, wet weather seriously reduces the effectiveness of most bike brakes. According to *Pedal Cycle Braking Performance: Effects of Brake Block and Rim Design* (Watt, TRRL 1980), some common bicycle brakes take over four times as far to stop in the rain as they do under dry conditions. Further, bikes equipped with aluminum alloy rims stop between twice and four times as quickly in the rain as similar bikes equipped with steel rims.

Complicating all these factors are the varying abilities of the riders themselves. Skilled bicyclists can stop far more quickly than can unskilled riders.

As a result, stopping sight distances are important factors to consider, particularly when designing curves and intersections on separate trail systems.

## Design options

The rest of this manual describes specific design features and approaches for accommodating bicyclists both on- and off-road. The topics include:

- Roadway improvements
- Bicycle lanes
- Bicycle routes
- Bicycle paths
- Supplemental facilities
- Operation and maintenance